Ultrastructure and Early Development of the Pore Plate Sensilla of Gymnомерus laevipes (Shuckard) (Vespoidea, Eumenidae)

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Received April 25, 1983
Accepted in revised form July 4, 1983

Summary

The oval pore plates (approx. 17 μm long) are separated from the antennal cuticle by a furrow, the inner wall of which is flexible. The thin perforated plates are strengthened by an encircling and a middle ledge, the latter of which branches into about 100 almost parallel rims. Each pore plate is innervated by about 20 sense cells. The dendrites fork into numerous branches occupying the outer receptor lymph cavity below the perforated plate. Each pore plate is associated with one thecogen cell, two trichogen cells, one tormogen cell and one “envelope cell 4”. A so-called “additional cell” surrounds the sensillum in the imaginal stage. The envelope cells in the later of the two pupal stages examined, have reached an arrangement which immediately precedes the secretion of the cuticulin layer. The surface of the duplicate trichogen cells is almost equal in area to the completed perforated plate. A dendritic sheath, entirely reduced in the imago, protrudes into the exuvial space, where it encloses a single dendrite.

In the younger pupal stage the “Sensillenanlage” forms a crater, whereby envelope cell 4 overtops the other envelope cells. The distal ends of the trichogen cells are divided into several appendages that form the bottom of the “crater”.

Keywords: Hymenoptera; Olfactory sensilla; Sensillum placodeum; Trichogen cell doubling.

1. Introduction

The cuticular apparatus of the pore plates on the antennae of the Hymenoptera aculeata consists of round or more or less elliptical perforated plates. These can either be flush with the antennal surface or rise slightly above it.

The first investigations of the pore plate sensilla of diverse species of Vespoidea were carried out by KRAEPELIN (1883), SCHENK (1903) and VOGEL (1923). However only WACKER (1925) provided really accurate descriptions of the cuticular structures of the pore plates of Dolichovespula saxonica, Vespuía rufa and Vespuía vulgaris (Vespidae) and those of Symmorphus crassicornis and Gymnомерus laevipes (Eumenidae). The fine structure of the pore plate sensilla of Hymenoptera aculeata was investigated in Apis mellifica (RICHARDS 1952, KRAUSE 1960, SIEFER and SEKHON 1961, SCHNEIDER and STEINBRECHT 1968), Bombus terrestris and Anthidium manicatum (Apoidea) (KRAUSE 1960). So far the only attempt to describe the fine structure of the pore plates of a yellow jacket (Vespula germanica) was made by KRAUSE (1960). But some misinterpretations were unavoidable due to the poorly-developed electron microscopic techniques at that time.

Ontogenetic investigations confirmed that the “Bauplan” of sensilla placodea corresponds to that of insect hair sensilla, but there is an increase in the number of envelope cells (STEPPER et al. 1983, SCHMIDT and KUHBRANDNER 1983). Pore plate development from the deposition of the cuticulin layer to the imaginal stage is described for Pimpla (Ichneumonidae) by STEPPER et al. (1983). This study describes the early development of pore plates in the young pupal stages before secretion of the cuticulin layer for the first time.

The ontogeny of olfactory sensilla of other holometabolous insects is only known in the case of the basiconic sensilla of Necrophorus (ERNST 1972).
2. Material and Methods

2.1. Material

Nests of Gymnomerus laevipes were found in dead twigs of neglected blackberry bushes near Karlsruhe. The antennae of pupae were fixed at different stages of development. The relative age of the pupae was estimated by the degree of colouring of the eyes and the cuticle.

2.2. Scanning Electron Microscopy (SEM)

Antennae of freshly emerged imagines dried in air were used. The antennae were cleaned with detergents for 2 hours and dehydrated in an ascending series of acetone. The antennae then were soaked in benzine for 15 hours. After drying in air they were mounted on holders and sputtered with gold. A few antennae were macerated in KOH (10%) and cut with a razor blade to expose the inner cuticular structures. The preparations were examined in a Cambridge Stereoscan 180.

2.3. Transmission Electron Microscopy (TEM)

Antennae of pupae and imagines were cut using a razor blade and fixed in a solution of 2% OsO₄ in veronal acetate buffer for 2 hours (335 mosm, pH 7.2; 4°C). After washing in buffer solution the pieces of the antennae were dehydrated in an increasingly concentrated series of acetone and embedded in Spurr’s medium. Serial sections were made in a Reichert microtome OMU II using glass-knives. The sections were stained in lead citrate and examined in a Zeiss 9 S-2.

3. Results

The number of segments on the antennae of Gymnomerus differs between the sexes the female having 12, the male 13 segments. In the male the terminal five segments of the flagellum form a spirally-shaped tip. The first two antennal segments (scapus and pedicellus) of both sexes lack pore plates. The following 10 segments of the female flagellum all bear pore plate sensilla, while the two segments at the tip of the male flagellum have no plate-shaped sensilla. The sensilla cover the whole surface of the segments of the female flagellum except the 1st segment (= 3rd segment of the antenna), while only three segments of the male flagellum (segments 3–5) are completely covered by pore plates. On the female flagellum about 1,400 pore plates were counted in SEM photographs. The flagellum of the male, however, had only about 900 sensilla of this type.

The pore plates are not the only sensilla on the flagellum of Gymnomerus. Sensilla trichodea, s. coeloconica and small and large s. basiconica are also present. The large s. basiconica are only to be found on the inner lateral side of the antennal segments.

3.1. Imaginal Sensillum

3.1.1. Cuticular Structures

The pore plates of Gymnomerus are oval and parallel to the longitudinal axis of the antenna. Each sensillum is encircled by a cuticular border which is separated from the plate by a deep furrow (Fig. 1a). The pore plates are about 17 µm long and almost 4.5 µm wide (exclusively the cuticular border). The plate bulges slightly as shown in Fig. 3b; sometimes it looks roof-shaped in SEM.